

**BUILDING STRUCTURE DESIGN OF HOTEL 6 (SIX)
FLOORS USING INTERMEDIATE MOMENT RESISTING
FRAME (IMRF) IN YOGYAKARTA**



Submitted to Qualify the Requirement
To Achieve Bachelor Degree of Civil Engineering

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UNIVERSITAS MUHAMMADIYAH SURAKARTA**

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Surakarta, 5 August 2020

Author



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BUILDING STRUCTURE DESIGN OF HOTEL 6 (SIX) FLOORS USING INTERMEDIATE MOMENT RESISTING FRAME (IMRF) IN YOGYAKARTA

Abstraksi

Tingginya jumlah wisatawan yang berkunjung ke kota Yogyakarta semakin meningkat setiap tahun, baik wisatawan lokal, regional, maupun internasional. Hal ini tentu membuat kebutuhan tempat tinggal sementara seperti hotel semakin meningkat. Untuk tercapainya hal tersebut, maka perlunya sebuah perencanaan hotel yang sesuai dengan standar. Untuk menyelesaikan permasalahan tersebut direncanakan hotel enam lantai menggunakan Sistem Rangka Pemikul Momen Menengah (SRPMM). Perencanaan gedung ini mencakup struktur atap, struktur pelat dan tangga, struktur gedung utama (Kolom dan Balok), serta struktur bawah (Pondasi). Analisa perencanaan struktur gedung menggunakan *software* SAP2000 dengan pemodelan 3D. Perencanaan struktur gedung mengacu pada SNI-1726:2012 (Tata Cara Perencanaan Ketahanan Gempa Untuk Struktur Bangunan Gedung dan Non Gedung), SNI-2847:2013 (Persyaratan Beton Struktural Untuk Bangunan Gedung). Mutu bahan yang digunakan perencanaan beton bertulang (f'_c) 25 MPa, dan kualitas tulangan utama (f_y) 400 MPa dan tulangan geser (f_y) 240 MPa. Struktur kolom direncanakan dengan dimensi 600x600 mm, 550x550 mm, dan 500x400 mm, sedangkan ukuran balok direncanakan dengan dimensi 300x800 mm dan 200x400 mm. Struktur bawah menggunakan pondasi tiang pancang dengan diameter 400 mm dengan kedalaman 12 m, ukuran *pilecap* 2400x2400x1250 mm untuk 4 tiang, dan ukuran sloof adalah 300x800 mm.

Kata Kunci : Perencanaan Hotel, Sistem Rangka Pemikul Momen Menengah (SRPMM), Pemodelan 3D, Mutu Bahan

Abstract

The high number of tourists visiting the city of Yogyakarta is increasing every year, both local, regional and international tourists. This certainly increases the need for temporary housing such as hotels. To achieve this, it is necessary to have a hotel plan in accordance with standards. To solve this problem, a six-story hotel is planned to use the Intermediate Moment Resisting Frame System (IMRF). This building plan includes the roof structure, slab and staircase structures, the main building structure (Columns and Beams), and the substructure (foundation). Analysis of building structure planning using SAP2000 software with 3D modeling. Building structure planning refers to SNI-1726: 2012 (Earthquake Resistance Planning Procedures for Building and Non-Building Structures), SNI-2847: 2013 (Structural Concrete Requirements for Buildings). The quality of the materials used is reinforced concrete planning (f'_c) 25 MPa, and the quality of the main reinforcement (f_y) 400 MPa and shear reinforcement (f_y) 240 MPa. The column structure is planned with dimensions of 600x600 mm, 550x550 mm, and 500x400 mm, while the beam sizes are planned with dimensions of 300x800 mm and 200x400 mm. The lower structure uses a pile foundation with a diameter of 400

mm with a depth of 12 m, a pile cap size of 2400x2400x1250 mm for 4 piles, and a sloof size of 300x800 mm.

Keywords: Hotel Planning, Intermediate Moment Resisting Frame (IMRF), 3D Modeling, Material Quality

1. INTRODUCTION

The city of Yogyakarta is the capital and centre of government of the Special Region of Yogyakarta, Indonesia. The city of Yogyakarta is the fourth largest city in the southern part of Java. Yogyakarta is also referred to as a city of students and cultural cities. The increasing number of tourists visiting the city of Yogyakarta is increasing every year, both local, regional and international tourists. This certainly makes the need for temporary accommodation such as hotels is increasing.

The choice of hotel buildings is because hotels are one of the most effective residence solutions for people on vacation. In the construction of this hotel using concrete construction, because concrete is one of the constructions that are often used in Indonesia. The design of the hotel will be planned 6 storey using the Intermediate Moment Resisting Frame method.

2. METHOD

Design Stage

The stages of the research are arranged systematically and logically based on existing basic theories to achieve the objectives:

- 1) Step I : Collection of data
- 2) Step II : Draw a hotel plan
- 3) Step III : Planning of roof, stair and slab
- 4) Step IV : Assume first dimension of Column and Beam
- 5) Step V : Determine the dimensions of the beam and column
- 6) Step VI : Planning Foundation
- 7) Stage VII : Drawing detail planning

For this final assignment scheme can be seen in Figure I

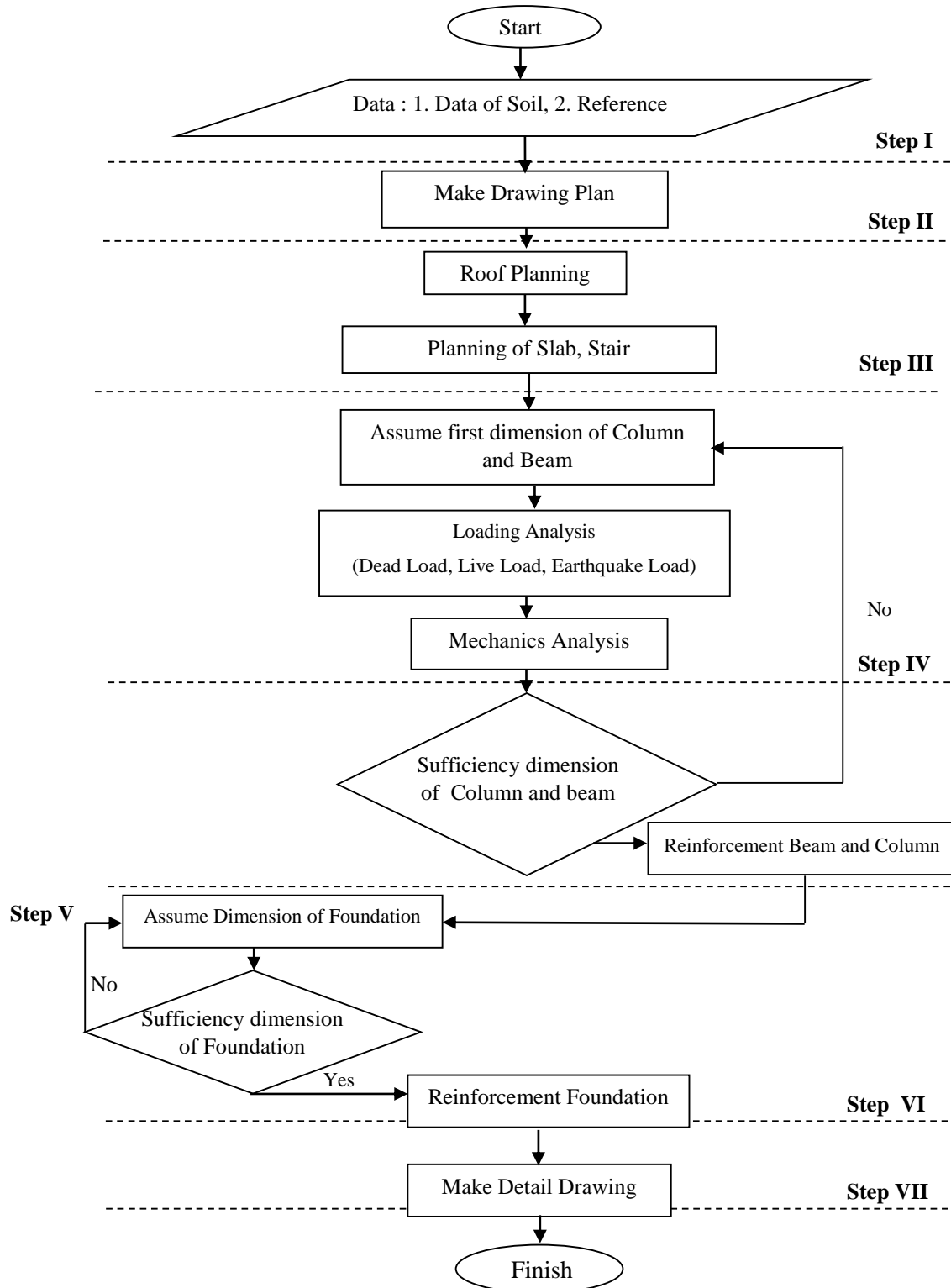


Figure 1. Scheme the Planning Method

3. RESULT AND DISCUSSION

3.1 Earthquake Load Analysis

1) Variety Combination

Determining the type of spectrum response mode refers to SNI 03-1726-2002 Article 7.2.2 as follows:

Summarizing the response of variance for irregular buildings that have natural vibrations times close together, performed by the CQC (Complete Quadratic Combination) method. Natural vibration time is considered close together, if the difference in value is less than 15%. For irregular building structures that have natural vibrations that are far apart, the sum of the various responses can be done by the SRSS (Square Root of the Sum of Squares) method.

Table 1 Periods

Mode	Periods (T)	ΔT (%)	Mode	Periods (T)	ΔT (%)
1	1,38235	5,525%	10	0,18723	5,500%
2	1,30597	3,273%	11	0,17693	3,225%
3	1,26323	63,965%	12	0,17122	10,198%
4	0,45521	5,374%	13	0,15376	0,157%
5	0,43075	3,294%	14	0,15352	1,961%
6	0,41656	35,912%	15	0,15051	0,521%
7	0,26696	5,487%	16	0,14973	1,793%
8	0,25232	3,718%	17	0,14704	0,663%
9	0,24293	22,931%	18	0,14607	-

ΔT : different period / time vibration is calculated by

$$\Delta T = (T1 - T2) / T1 \times 100\%$$

Based on these calculations, it appears that the difference in structure vibration time exceeds 15%, so a combination of SRSS methods should be used.

2) Participating Mass Ratio

Based on SNI-1726-2012 (Article 7.9.1), analysis must be carried out to determine the range of natural vibrations for the structure. The analysis must

include a sufficient number of variations to get the combined mass participation of at least 90% of the actual mass in each orthogonal horizontal direction of the response reviewed by the model.

Modal Participating Mass Ratios

File View Format-Filter-Sort Select Options

Units: As Noted

Modal Participating Mass Ratios

	OutputCase Text	StepType Text	StepNum Unitless	Period Sec	UX Unitless	UY Unitless	UZ Unitless	SumUX Unitless	SumUY Unitless	
▶	MODAL	Mode	1	1.38235	0.00004076	0.00095	0.0000005656	0.00004076	0.00095	0.0
	MODAL	Mode	2	1.305973	0.8564	0.000015	0.00000005717	0.85644	0.00096	0.0
	MODAL	Mode	3	1.263234	0.00001357	0.85398	0.00000007515	0.85646	0.85495	0.0
	MODAL	Mode	4	0.455209	0.00001234	0.00012	0.000001231	0.85647	0.85506	0.
	MODAL	Mode	5	0.430747	0.09797	0.000003091	0.0000002026	0.95444	0.85507	0.
	MODAL	Mode	6	0.416957	0.00000248	0.10145	0.00000003704	0.95444	0.95651	0.
	MODAL	Mode	7	0.266964	0.000003016	0.00005316	0.0000003902	0.95444	0.95657	0.
	MODAL	Mode	8	0.252315	0.03002	0.0000003603	0.00000004604	0.98446	0.95657	0.
	MODAL	Mode	9	0.242934	0.0000002317	0.02933	1.218E-13	0.98446	0.98589	0.
	MODAL	Mode	10	0.187227	0.00000109	0.00002214	0.0000005964	0.98446	0.98591	0.
	MODAL	Mode	11	0.17693	0.01077	0.00000001247	0.0000005093	0.99523	0.98591	0.
	MODAL	Mode	12	0.171224	0.0000000194	0.00988	0.00000001129	0.99523	0.99579	0.
	MODAL	Mode	13	0.153763	0.000000204	0.000001587	0.503	0.99523	0.9958	
	MODAL	Mode	14	0.153521	0.00001286	0.00003582	0.03469	0.99525	0.99583	
	MODAL	Mode	15	0.15051	0.00001873	0.00002291	0.0135	0.99526	0.99586	
	MODAL	Mode	16	0.149726	0.000003122	0.0000008694	0.15886	0.99527	0.99586	
	MODAL	Mode	17	0.147041	0.000001463	0.00000001148	0.0212	0.99527	0.99586	
	MODAL	Mode	18	0.146066	0.0000002881	0.0000003961	0.000002148	0.99527	0.99586	

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Figure 1 Participating Mass Ratio

3) Base Shear

TABLE: Base Reactions				
OutputCase	CaseType	StepType	GlobalFX	GlobalFY
Text	Text	Text	KN	KN
Quake X	LinRespSpec	Max	5517,628	1179,868
Quake Y	LinRespSpec	Max	1148,909	5516,853
statis x	LinStatic		-6489,19	-5,639E-09
statis y	LinStatic		-8,29E-09	-6489,19

Figure 2 Base Shear

X-direction (read GlobalFX column, absolute value is taken):

V Static (Static x) = 6189,19 kN

V Dynamic (Quake x)= 5516,853 kN

85% V Static = 5515,8115 kN So, V Dynamic > 85% V Static (OK)

Y-direction (read GlobalFX column, absolute value is taken):

V Static (Statis y) = 6189,19 kN

V Dynamic (Quake y)= 5517,628 kN

85% V Static = 5515,8115 kN So, V Dynamic > 85% V Static (OK)

3.2 Design of Roof

Design of roof using gable frame. Generally, gable frames use WF / IWF form profiles, both for columns and rafter. Planning a gable structure includes: Planning of purlin, sag rod, rafter, Column, Connection, Column base plate.

3.3 Design of Slab

Reinforced concrete slab with horizontal direction, and the loads perpendicular with slab. The thickness of the slab is relatively small when compared to the long and wide span. Basically, reinforcement of slab is divided into 2 types, namely one-way slab planning and two-way slab planning. Main reinforcement for slab is D10 – 150 and stirrup D8 – 250.

3.4 Design of Stair

Stairs are a means of connecting between the first level floor with another level floor. For the design of the stairs begins by determining the size of the steps and determining the weight and moment of the stairs. Next, the calculation of reinforcement plates stairs and intermediate landing. Main reinforcement D10 – 100 and stirrup D8 – 200.

3.5 Design of Beam

Loads that work on the beam are usually in the form of flexural loads, shear loads and torque, so it needs reinforcing steel to withstand these loads. Reinforcement needed in the form of longitudinal reinforcement and shear reinforcement. The dimensions and reinforcement of beams are calculated based on the need to work, but still consider the occurrence of plastic hinge. For beam, plastic hinge installed on both ends of the beam. In areas along $2h$, reinforcing are close than stirrup outside of $2h$. Stirrup reinforcement plastic hinge area D8 – 125 and outside plastic hinge D8 – 225.

3.6 Design of Column

Column as supporting load from beam and plate, this load is compressive axial load. Therefore the column is a structure that supports axial loads. Column dimensions and reinforcement are also calculated based on the necessary load, taking into consider plastic hinge. For the plastic hinge column installed at both ends of the column. The location of the plastic hinge is installed on the distance l_0 measured from the face of the joint. The area along the length of the reinforcing bar is close than the outside of l_0 . Stirrup reinforcement plastic hinge area D10 – 125 and outside plastic hinge D10 – 125.

4. CLOSING

4.1 Conclusion

1) Design of Gable Frame

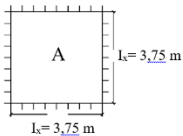
Based on result of calculation analysis, obtained roof structure design as follows:

- a. Purlin profile that used is Lip Channel 100.50.20.3,2 with steel quality BJ 41, distance between purlin is 1,38 m.
- b. Rafter using steel I profile 125.60.6.8 with steel quality BJ 41, distance between truss 3,75 m. Connections of steel profile that use type bolt A307, diameter 8 mm with the number of installed bolt is 3x2.

2) Design of Slab and Stair

a. Slab

Table 4.1 Reinforcement of Roof Slab

Type of Slab	Necessary load (kN.m)	Main Reinforce ment counted (mm)	Main Reinforce ment installed (mm)	Second Reinforc ement counted (mm)	Second Reinforc ement installed (mm)	Design Moment (kN.m)
	$M_{lx}^{(+)} = 1,573$	Ø10 - 150	Ø10 - 150			8,148
	$M_{ly}^{(+)} = 1,573$	Ø10 - 200	Ø10 - 150			5,325
	$M_{lx}^{(-)} = 3,895$	Ø10 - 150	Ø10 - 150	Ø8 - 250	Ø8 - 250	8,148
	$M_{ly}^{(-)} = 3,895$	Ø10 - 200	Ø10 - 150	Ø8 - 250	Ø8 - 250	5,325

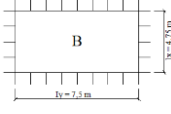
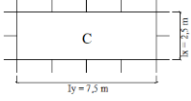
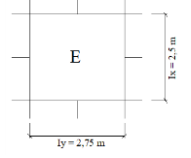
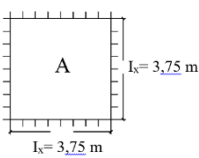
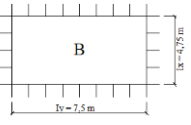
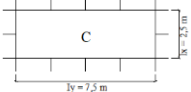
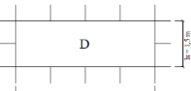
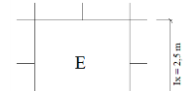
Type of Slab	Necessary load (kN.m)	Main Reinforce ment counted (mm)	Main Reinforce ment installed (mm)	Second Reinforc ement counted (mm)	Second Reinforc ement installed (mm)	Design Moment (kN.m)
	$M_{lx}^{(+)} = 1,112$	Ø10 - 150	Ø10 - 150			8,148
	$M_{ly}^{(+)} = 0,481$	Ø10 - 200	Ø10 - 150			5,325
	$M_{tx}^{(-)} = 2,373$	Ø10 - 150	Ø10 - 150	Ø8 - 250	Ø8 - 250	8,148
	$M_{ty}^{(-)} = 1,712$	Ø10 - 200	Ø10 - 150	Ø8 - 250	Ø8 - 250	5,325
	$M_{lx}^{(+)} = 1,359$	Ø10 - 150				8,148
	$M_{ly}^{(+)} = 0,259$	Ø10 - 200				5,325
	$M_{tx}^{(-)} = 2,685$	Ø10 - 150	Ø10 - 150	Ø8 - 250	Ø8 - 250	8,148
	$M_{ty}^{(-)} = 1,844$	Ø10 - 200	Ø10 - 150	Ø8 - 250	Ø8 - 250	5,325
	$M_{lx}^{(+)} = 0,809$	Ø10 - 150				8,148
	$M_{ly}^{(+)} = 0,679$	Ø10 - 200				5,325
	$M_{tx}^{(-)} = 1,909$	Ø10 - 150	Ø10 - 150	Ø8 - 250	Ø8 - 250	8,148
	$M_{ty}^{(-)} = 1,747$	Ø10 - 200	Ø10 - 150	Ø8 - 250	Ø8 - 250	5,325

Table 4.2 Reinforcement of Floor Slab

Type of Slab	Necessary load (kN.m)	Main Reinforce ment counted (mm)	Main Reinforce ment installed (mm)	Second Reinforc ement counted (mm)	Second Reinforc ement installed (mm)	Design Moment (kN.m)
	$M_{lx}^{(+)} = 3,656$	Ø10 - 125	Ø10 - 125			12,4116
	$M_{ly}^{(+)} = 3,656$	Ø10 - 150	Ø10 - 125			9,2789
	$M_{tx}^{(-)} = 9,053$	Ø10 - 125	Ø10 - 125	Ø8 - 200	Ø8 - 200	12,4116
	$M_{ty}^{(-)} = 9,053$	Ø10 - 150	Ø10 - 125	Ø8 - 200	Ø8 - 200	9,2789
	$M_{lx}^{(+)} = 2,616$	Ø10 - 125	Ø10 - 125			12,4116
	$M_{ly}^{(+)} = 1,131$	Ø10 - 150	Ø10 - 125			9,2789
	$M_{tx}^{(-)} = 5,587$	Ø10 - 125	Ø10 - 125	Ø8 - 200	Ø8 - 200	12,4116
	$M_{ty}^{(-)} = 4,031$	Ø10 - 150	Ø10 - 125	Ø8 - 200	Ø8 - 200	9,2789

Type of Slab	Necessary load (kN.m)	Main Reinforce ment counted (mm)	Main Reinforce ment installed (mm)	Second Reinforc ement counted (mm)	Second Reinforce ment installed (mm)	Design Moment (kN.m)
	$M_{lx}^{(+)} = 2,786$	Ø10 - 125	Ø10 - 125			12,4116
	$M_{ly}^{(+)} = 1,315$	Ø10 - 150	Ø10 - 125			9,2789
	$M_{tx}^{(-)} = 5,881$	Ø10 - 125	Ø10 - 125	Ø8 - 200	Ø8 - 200	12,4116
	$M_{ty}^{(-)} = 4,410$	Ø10 - 150	Ø10 - 125	Ø8 - 200	Ø8 - 200	9,2789
	$M_{lx}^{(+)} = 1,170$	Ø10 - 125	Ø10 - 125			12,412
	$M_{ly}^{(+)} = 0,223$	Ø10 - 150	Ø10 - 125			9,279
	$M_{tx}^{(-)} = 2,312$	Ø10 - 150	Ø10 - 125	Ø8 - 200	Ø8 - 200	12,412
	$M_{ty}^{(-)} = 1,588$	Ø10 - 150	Ø10 - 125	Ø8 - 200	Ø8 - 200	9,279
	$M_{lx}^{(+)} = 1,934$	Ø10 - 125	Ø10 - 125			12,412
	$M_{ly}^{(+)} = 1,625$	Ø10 - 150	Ø10 - 125			9,279
	$M_{tx}^{(-)} = 4,565$	Ø10 - 125	Ø10 - 125	Ø8 - 200	Ø8 - 200	12,412
	$M_{ty}^{(-)} = 4,178$	Ø10 - 150	Ø10 - 125	Ø8 - 200	Ø8 - 200	9,279

b. Stair

Table 4.3 Reinforcement of Stair Slab Design

Frame	Frame position	M_u (kN-m)	M_d (kN-m)	Main reinforce ment counted	Main reinforce ment installed	Second reinforc ement counted	Second reinforce ment installed
Stair	Left	-21,422	24,771	D10 -100	D10 -100	D8 -200	D8 -200
	Field	10,828	11,525	D10 -225	D10 -100	D8 -200	D8 -200
	Right	-13,940	14,666	D10 -175	D10 -100	D8 -200	D8 -200
Landing	Left	-13,940	14,666	D10 -175	D10 -175	D8 -200	D8 -200
	Field	-4,961	11,525	D10 -225	D10 -175	D8 -200	D8 -200
	Right	0	11,525	D10 -225	D10 -175	D8 -200	D8 -200

3) Main Structure Design Using IMRF

a. Beam Dimension and Installed Reinforcement

Table 4.4 Dimension and Reinforcement of Beam

Beam Dimension	Position	Main Reinforcement		Main Reinforcement	
		Upper	Under	Plastic Hinge	Outside Plastic Hinge
300/800	Left	5D22	3D22	D8-125	
	Field	3D22	3D22		D8-225
	Right	5D22	3D22	D8-125	

Beam Dimension	Position	Main Reinforcement		Main Reinforcement	
		Upper	Under	Plastic Hinge	Outside Plastic Hinge
200/400	Left	3D19	3D19	D8-85	
	Field	3D19	3D19		D8-150
	Right	3D19	3D19	D8-85	

b. Column Dimension and Installed Reinforcement

Table 4.5 Dimension and Reinforcement of Column

Column Dimension	Longitudinal Rebar	Stirrup	
		Plastic Hinge	Outside Plastic Hinge
600/600	26D25	D10-125	D10-125
550/550	16D25	D10-125	D10-125
500/400	18D25	D8-125	D8-125

4) Design of Foundation

Bottom Structure consist of pile foundation and sloof

- a. Using diameter of pile 400 mm, a pile length of 12 m. The depth of foundation is 12 m.
- b. Pile cap is use main reinforcement D25-150 on top and bottom position, with dimension of pile cap is 2400x2400x1250 mm, using 4 piles.
- c. Sloof dimension and installed reinforcement

Table 4.6 Dimension and Reinforcement of Sloof

Sloof dimension	Position	Longitudinal Reinforcement	Stirrup	
			Plastic Hinge	Outside Plastic Hinge
300/800	Left	5D22	D8-175	D8-225
	Middle	3D22		
	Right	5D22	D8-175	D8-225

4.2 Suggestion

1. Buildings should be planned with attention to various aspects so that safe and economical results can be obtained.
2. The process of modeling the structure using SAP2000 must be done carefully, so that the results released can be accurate.
3. Building material choices are adjusted with availability on the market.

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